




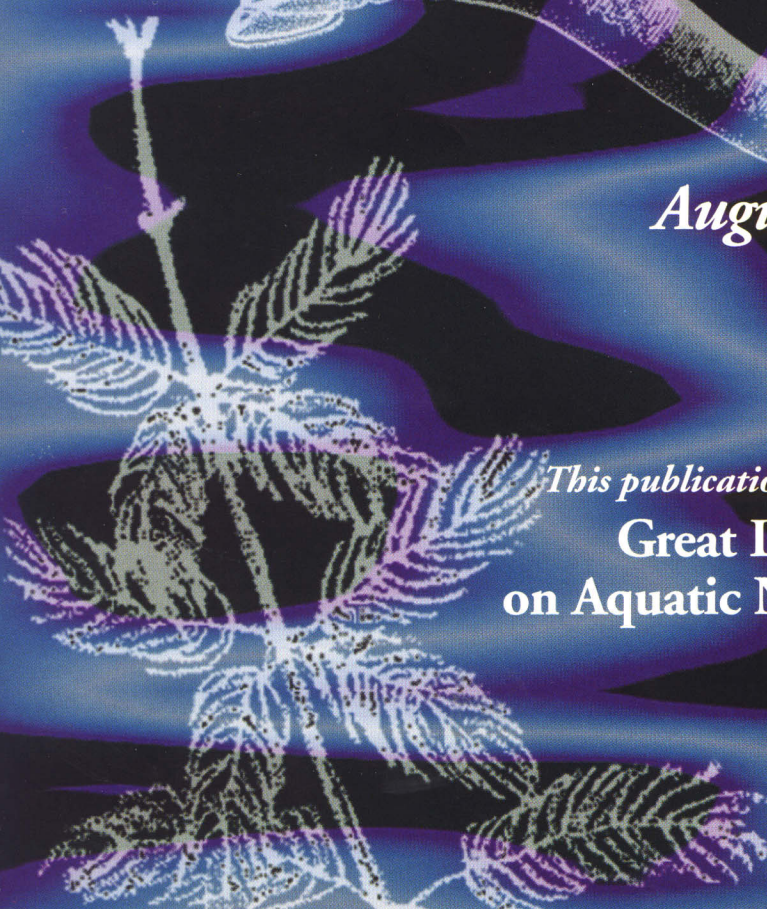
# Biological Invasions



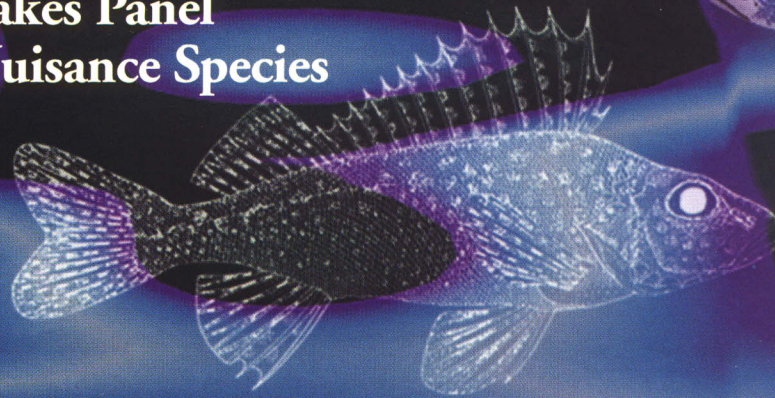
*How aquatic nuisance species are entering  
North American waters, the harm they cause  
and what can be done to solve the problem*



*August 1998*



*This publication is a product of the  
Great Lakes Panel  
on Aquatic Nuisance Species*





# The Battle Against Aquatic Nuisance Species

Immediate and strategic action is critical for effective ANS prevention and control in North American waters. While control efforts have successfully limited the spread of some species, no known control options exist for others. Prevention of new ANS introductions, coupled with long-term research on control strategies, is a priority. To strengthen ANS prevention and control efforts, much more needs to be done at all levels of government, and in partnership with all who use and benefit from aquatic resources.

## Federal Initiatives

- ♦ The U.S. Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (the Act) is a first line of defense against ANS invasions. The Act provides an institutional framework that promotes and coordinates research, develops and applies prevention and control technologies, establishes national priorities, educates and informs citizens, and coordinates public programs.

The Act was reauthorized through the National Invasive Species Act of 1996. However, only modest funding has been appropriated to date. Enhanced funding is critical if the Act is to effectively fulfill its ANS prevention and control mandate. Broad bipartisan support from all regions of the United States also is needed.

- ♦ U.S. ballast water regulations mandated under the Act help limit introductions through transoceanic shipping. These regulations require that vessels bound for the Great Lakes exchange their freshwater ballast, replacing it with open-ocean salt water that contains organisms not likely to survive in freshwater.

The National Invasive Species Act of 1996 reauthorizes and expands the Act to include a national ballast water management program. Guidelines for this enforceable program will be in place by the fall of 1998. Similar to the Great Lakes program, ballast exchange, or an environmentally sound alternative pre-approved by the Coast Guard, will satisfy ballast treatment requirements. The 1996 amendments also establish a national ballast technology demonstration program to promote the development of safer and more effective methods of ballast treatment.

- ♦ Long-term research programs conducted by the U.S. Department of Agriculture (USDA) and U.S. Army Corps of Engineers have helped advance biological control strategies (e.g., introduction of native insects) focusing on nonindigenous aquatic weeds such as the water hyacinth and alligator weed. Both are problem species in the southern United States.

Further protection against the introduction and spread of nonindigenous aquatic weeds is provided under the Federal Noxious Weed Act (FNWA). However, new regulations under FNWA are needed to enhance the ability of the USDA to prevent the interstate spread of listed federal noxious weeds.

## Regional/Binational Initiatives

- ♦ The Great Lakes Panel on Aquatic Nuisance Species, comprised of U.S. and Canadian public and private sector

representatives, is identifying Great Lakes priorities, coordinating research and information/education efforts, making recommendations to the federal government, and raising public awareness of ANS issues. The Panel requires adequate financial support to meet its many obligations as called for in the Act.

To help strengthen ANS prevention and control on a national scale, ANS coordinating panels (like the Great Lakes Panel and the Western Regional Panel) need to be established in other regions of the country.

- ♦ The Great Lakes Fishery Commission, established in 1955 by the United States and Canada, has developed and implemented a sea lamprey control program in the Great Lakes, reducing populations to 10 percent of pre-control levels. Funding for this program must be maintained if effective sea lamprey control is to continue.
- ♦ A Great Lakes ballast technology demonstration project is testing innovative methods to more effectively prevent ANS transport into the Great Lakes and other North American waters via commercial vessels. Continued support for such projects, as well as application of promising technologies, is essential.

## State/Provincial Initiatives

- ♦ Water users throughout the Great Lakes Basin, and beyond, rely upon state/provincial agencies, Sea Grant programs and other groups for advice and assistance on ANS prevention and control measures. For example, the regulatory and information/education programs of the Minnesota Department of Natural Resources have limited the spread of Eurasian watermilfoil as indicated by an overall decrease in the number of newly infested lakes over the past decade.
- ♦ Uniform guidelines for recreational boating and other activities are needed to minimize the introduction and spread of aquatic nuisance species into inland waters across North America. State/provincial regulations to prohibit movement of nonindigenous aquatic nuisance species between inland waters are critical as well. Consistent and effectively delivered messages across all jurisdictions are important.
- ♦ State management plans for ANS prevention and control, as called for in the Act, are being developed or implemented in several Great Lakes states. A model state management plan, developed under the auspices of the Great Lakes Panel, is providing a regional framework for such plans.

Federal and state/provincial funding is needed to implement these plans and to develop effective public/private sector partnerships.

## Local/Private Initiatives

- ♦ The active involvement of lake associations, fishing clubs, boating organizations and other affected water users is needed to ensure that laws, policies and programs for ANS prevention and control are successfully implemented.
- ♦ Nongovernmental organizations, municipal water suppliers, industrial water users and other private companies have played an important role in ANS prevention and control initiatives through research, development and application of management techniques and information/education activities. Such efforts should be continued, and promising management strategies and technologies shared with interested parties throughout North America.



# Valuable Water Resources at Risk

Nonindigenous aquatic nuisance species can have significant economic and ecological impacts, as illustrated by the following examples:

- ♦ Great Lakes water users spend tens of millions of dollars on zebra mussel control every year. Affected municipalities and industries, using large volumes of Great Lakes water, expend approximately \$360,000 per year on zebra mussel control; small municipalities average \$20,000. Nuclear power plants also have paid a heavy price for zebra mussel control, with average annual costs of \$825,000 per affected plant. As the zebra mussel spreads to inland lakes and rivers across North America, such as the Mississippi River Basin and Lake Champlain, so do the costs to water users.
- ♦ Zebra mussel infestations cause pronounced ecological changes in the Great Lakes and major rivers of the central United States. The zebra mussel's rapid reproduction, coupled with consumption of microscopic plants and animals, affects the aquatic food web and places valuable commercial and sport fisheries at risk. In waters infested with the zebra mussel, large blooms of potentially toxic blue-green algae have been observed in waters such as Saginaw Bay, Lake Huron and the western basin of Lake Erie.



**Zebra Mussels**

Credit: Ontario Ministry of Natural Resources

- ♦ In the western United States, aquatic ecosystems and water delivery systems (including drinking water facilities, irrigation systems and hydroelectric power plants) are particularly vulnerable to zebra mussel invasions. The potential damage to the quality and delivery of limited water resources could be devastating to cities, towns and homeowners as well as agricultural, industrial and recreational interests.
- ♦ Aggressive fish that have invaded the Great Lakes (such as the sea lamprey, ruffe and round goby) can harm native fish. Reductions in native fish populations (such as lake trout, walleye, yellow perch and whitefish) threaten a sport and commercial fishing industry that is valued at almost \$4.5 billion annually and supports approximately 81,000 jobs.



**Round Goby**

*Credit: David Jude*

- ♦ Nonindigenous aquatic nuisance plants, such as purple loosestrife, Eurasian watermilfoil, hydrilla and water hyacinth, quickly establish themselves, displacing native plants. Environmental and economic problems caused by the dense growth of these weeds include impairment of water-based recreation, navigation and flood control, degradation of water quality and fish and wildlife habitat, accelerated filling of lakes and reservoirs, and depressed property values.



**Purple Loosestrife**

Credit: Minnesota Department of Natural Resources

- ♦ Due to its rapid growth, the submersed nonindigenous aquatic plant, hydrilla, blocks agricultural irrigation canals and interferes with municipal water supply infrastructure. In California, state and federal agencies have expended nearly \$1 million per year for the past 20 years to remove this plant from inland waters. In Florida, the area infested with hydrilla has doubled in recent years covering 100,000 acres of inland waters. Annual maintenance control costs now exceed \$14 million. Hydrilla also causes ecological and economic damage in the Chesapeake Bay, South Atlantic states and the Gulf Coast, among others.
- ♦ ANS invasions pose serious health risks. A South American strain of human cholera bacteria was found in ballast tanks in the port of Mobile, Alabama, in November 1991. Earlier that year, cholera strains also were found in oyster and fin-fish samples in Mobile Bay, resulting in a public health advisory to avoid handling and/or eating raw oysters or seafood. Temporary closure of oyster beds caused a decline in regional consumer demand for shellfish.
- ♦ The Chinese mitten crab, now found in San Francisco Bay, is host to the oriental lung fluke, a parasite affecting humans and other mammals. The host snails needed to complete the lifecycle of the fluke are present in California and adjacent states, thus facilitating the establishment of fluke populations in the United States.



Credit: Minnesota Department of Natural Resources



# The Rise of Aquatic Nuisance Species in North American Waters

Invasions of nonindigenous aquatic nuisance species in North American waters have occurred since European colonization began nearly four centuries ago. The resulting environmental and economic impacts are increasingly problematic. The single largest source of unintentional introductions is transport via ocean vessels originating at foreign ports. Some species attach themselves to the hulls of ships, while others are carried in ballast water taken on by ships in foreign ports for stability. When ships reach their destinations, the nonindigenous species are released with ballast water discharge. Over the past century, as shipping time has become shorter with faster vessels, and as harbors have become less polluted, more species have been able to survive the journey and thrive in new waters. With continued expansion of international trade, new ANS introductions are likely to occur from waters around the globe.

ANS introductions and dispersal in North American waters also result from other activities that provide economic benefits, such as the aquaculture industry, aquarium trade, sport fish stocking, bait business and ornamental and landscape practices. Animal and plant species, such as the common carp, hydrilla, water hyacinth and rusty crayfish have been introduced and dispersed from these types of activities and have caused unexpected ecological and economic impacts.

## The Great Lakes

In the Great Lakes Basin alone, at least 139 nonindigenous aquatic species have become established since the early 1800s resulting primarily from ship-related introductions, removal of physical barriers with the building of canals, and accidental releases from aquaculture, bait, aquarium trade and horticultural activities. As use of the Great Lakes as a transportation route for commerce intensified, the rate of ANS introductions also increased. More than one-third of the organisms have been introduced in the past 35 years, a surge coinciding with the opening of the St. Lawrence Seaway, which permitted more and larger vessels to pass between the Great Lakes and ports throughout the world. Threatening the ecological and economic value of the Great Lakes and inland waters of the region are, among others, the sea lamprey, zebra mussel, purple loosestrife, Eurasian watermilfoil, ruffe and round goby.

## Coastal Waters

Ballast water has historically been the primary transport mechanism for introducing aquatic nuisance species to coastal waters of North America.

San Francisco Bay, a center of extensive international trade, hosts more than 210 introduced aquatic species. For nearly 150 years, this highly disturbed and vulnerable ecosystem has been exposed to continuous, large-scale inoculations of nonindigenous species through activities associated with commercial shipping and oyster farming. The importation of commercial oysters, commencing in the 1870s, allowed non-native species to hitchhike on the shells of oysters and packing materials shipped from the eastern U.S. coast and Japan. In the last decade, a new

species has arrived about every 12 weeks. Nonindigenous species, such as the shipworm, Amur River clam, European green crab, Asian clam, common carp and smooth cordgrass, cause damage to the bay's ecosystem and economic uses.



European Green Crab

Credit: Caroline Kopp

In the Gulf of Mexico, the marine/estuarine brown mussel, a southern hemisphere native, displaces native mollusks and threatens mangrove communities. The brown mussel, like the zebra mussel, encrusts hard surfaces. As the brown mussel's range expands, there is rising concern over the economic impacts that could result from fouling of water intake systems, shipping areas and offshore oil platforms.

In Chesapeake Bay, an area where large quantities of foreign ballast water are discharged, the threat from aquatic nuisance species is ominous. A recent study indicated that more than 90 percent of 70 vessels surveyed at Chesapeake Bay ports carried live organisms in their ballast, including barnacles, clams and mussels, microscopic plants and animals, and juvenile and adult fish. It is estimated that more than 100 nonindigenous aquatic species are established in the bay.

Ecosystems of Pacific and Atlantic coastal waters suffer from infestations of the European green crab, a harmful ballast stowaway that preys on commercially valuable oysters and clams. In the Pacific Northwest, the list of ANS introductions is growing rapidly due to ballast water. Up to 40 percent of all aquatic species in some estuaries and river systems are nonindigenous.

The new availability of Alaskan oil on the world market will open the doors for more ANS introductions via ballast water from ports of northeast Asia and elsewhere in the world. Of considerable concern is the transmission of fish pathogens and parasites from foreign ports, which could have a devastating impact on Alaskan fisheries.

## Inland Waters

Once introduced into the Great Lakes or coastal waters, many aquatic nuisance species spread to inland lakes, rivers, wetlands and waterways by way of barges, recreational watercraft, bait buckets, fish stocking and other human-assisted transport mechanisms. For example, the zebra mussel has spread from the Great Lakes by way of barge traffic and recreational boating, infesting many inland freshwater ecosystems. In the upper Mississippi River, the zebra mussel has degraded an economically valuable commercial mollusk fishery.

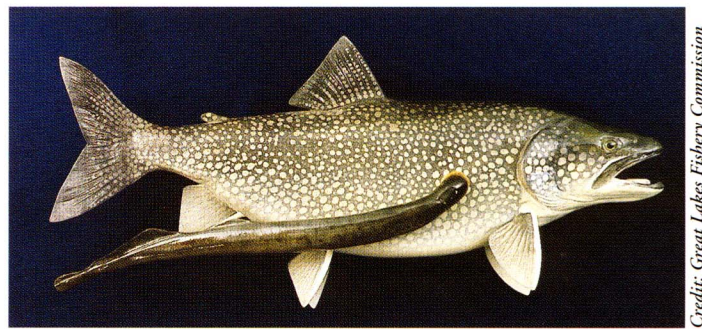
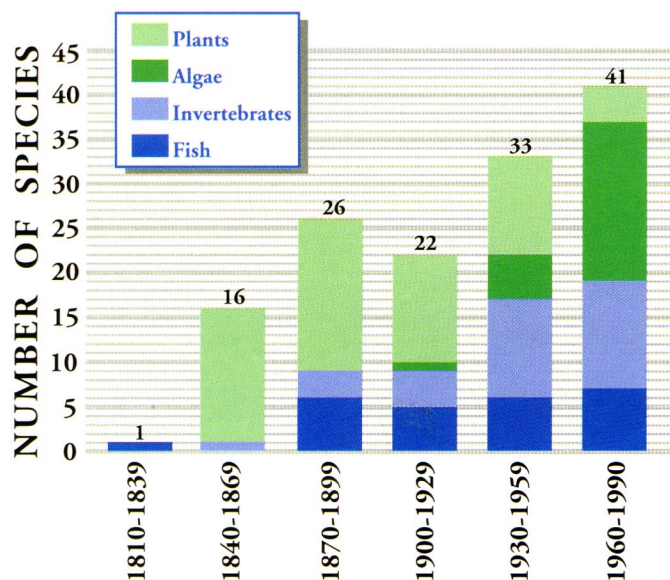
Whirling disease, a potentially fatal condition to young salmon and trout, is caused by a nonindigenous parasite that infects the fish cartilage and nervous system. Transmitted by infected stocked trout, whirling disease has damaged hatchery-reared fish stocks across the country as well as wild stocks in inland waters of the western United States. Wild stocks in the Great Lakes also have been shown to be infected.

Other inland aquatic invaders, such as the common carp, purple loosestrife, Eurasian watermilfoil, rusty crayfish, hydrilla and Asian clam, alter habitats, displace native species and impair recreational opportunities and public facilities using infested waters.



**A**n increasing number of nonindigenous (non-native) organisms, including aquatic animals and plants, are invading the Great Lakes and other coastal and inland waters in North America. In their native waters, these organisms may be relatively harmless. However, when transplanted to other waters, they can cause problems for native organisms, disturbing the balance of natural ecosystems and adversely affecting established uses of the resource. Nonindigenous aquatic species are introduced and spread by activities such as maritime commerce, recreational boating, sport fish stocking and accidental releases associated with the aquaculture industry, aquarium trade, bait business and horticultural practices. The North American invasion of nonindigenous aquatic nuisance species, such as the sea lamprey, zebra mussel, purple loosestrife, European green crab and hydrilla, has created ecological disasters with pronounced economic consequences for all who use or otherwise benefit from our aquatic ecosystems. As reported by the U.S. Congress, Office of Technology Assessment and subsequently by The New York Times, new introductions of nonindigenous species are increasing throughout the United States due to human-assisted transport. The situation continues to worsen. Prevention and control action is needed now to solve this pervasive problem.

### *A Timeline of Introductions of Nonindigenous Aquatic Species in the Great Lakes*



Credit: Great Lakes Fishery Commission

The sea lamprey, native to the Atlantic Ocean, invaded the Great Lakes through canal systems. The lamprey preys on large fish, such as whitefish, trout and salmon, threatening the Great Lakes sport and commercial fishery. Millions of dollars are spent annually to reduce populations to 10 percent of pre-control levels.

**A**quatic nuisance species from around the world often infest North American waters in the absence of natural predators, parasites, pathogens and competitors that would normally keep their numbers in check. Under the right conditions, non-native populations can dramatically increase, displacing native species, reducing biodiversity and limiting water-use activities. Once established, this form of biological pollution is difficult to manage and nearly impossible to eliminate, creating a costly burden for current and future generations. For example:

- ◆ The Great Lakes sport and commercial fishing industry, valued at almost \$4.5 billion annually, is at risk due to the growing numbers of nonindigenous mussels and fish, such as the zebra and quagga mussels, sea lamprey, ruffe and round goby.
- ◆ Large water users in the Great Lakes, including municipalities and industries, pay an average of \$360,000 per year to control zebra mussels, with documented cumulative costs of \$120 million from 1989-1994.
- ◆ Florida spends more than \$14 million per year to control a single nonindigenous aquatic plant, hydrilla.
- ◆ Human health and the Gulf of Mexico shellfish industry were recently threatened when a strain of human cholera bacteria from South America was transported to Mobile Bay, Alabama.

In the Great Lakes Basin and many other areas of North America, nonindigenous aquatic nuisance species (ANS) introductions are increasing, and tens of millions of dollars are being spent each year on ANS prevention and control. Immediate and strategic efforts are needed at federal, regional, state and local levels to avoid mounting environmental and economic costs.

◀ *A timeline of introductions of nonindigenous aquatic species in the Great Lakes, sorted by taxonomic group. The total number of species is indicated above each bar. Credit: E.L. Mills, J.H. Leach, J.T. Carlton, C.L. Secor, Journal of Great Lakes Research, 1993.*



# For More Information

The following agencies can provide further information on nonindigenous aquatic nuisance species in the Great Lakes and in other regions of the United States and Canada.

## Federal: U.S. and Canada

National Aquatic Nuisance  
Species Task Force ..... 703-358-2025

U.S. Fish & Wildlife Service ..... 703-358-1718

National Oceanic and Atmospheric  
Administration ..... 202-482-5181

U.S. Department of Agriculture, Animal  
and Plant Health Inspection Service ..... 202-720-5283

U.S. Geological Survey,  
Great Lakes Science Center ..... 734-214-7223

Canadian Department of Fisheries  
and Oceans ..... 905-336-4568

U.S. Coast Guard-Ninth District ..... 216-902-6056

Transport Canada/Canadian  
Coast Guard ..... 519-464-5127

## Regional/Binational

Great Lakes Commission/Great Lakes  
Panel on Aquatic Nuisance Species ..... 734-665-9135

Western Regional Panel on  
Aquatic Nuisance Species ..... 785-539-3474 Ext. 20

Great Lakes Fishery Commission ..... 734-662-3209

Chippewa-Ottawa Treaty  
Fishery Management Authority ..... 906-632-0043

Great Lakes Indian Fish and  
Wildlife Commission ..... 715-682-6619

Lake Carriers' Association ..... 216-621-1107

Northeast-Midwest Institute ..... 202-544-5200

Great Lakes Sport ..... 630-941-1351  
Fishing Council

Sea Grant National ..... 716-395-2516  
Aquatic Nuisance Species Clearinghouse

## Great Lakes States/Provinces

Illinois Department of ..... 217-782-6424  
Natural Resources

Illinois Natural History Survey ..... 847-872-8677

Illinois-Indiana Sea Grant ..... 217-333-9448

Indiana Department  
of Natural Resources ..... 317-232-4094

Michigan Department of  
Environmental Quality,  
Office of the Great Lakes ..... 517-335-4056

Michigan Sea Grant ..... 517-353-5508

Minnesota Department  
of Natural Resources ..... 651-297-1464

Minnesota Sea Grant ..... 218-726-8712

New York Department of  
Environmental Conservation ..... 518-457-0758

New York Sea Grant ..... 716-395-2638

Ohio Department  
of Natural Resources ..... 614-265-6344

Ohio Sea Grant ..... 614-292-8949

Pennsylvania Department ..... 717-772-4785  
of Environmental Protection ..... 717-787-9637

Wisconsin Department  
of Natural Resources ..... 608-266-9270

Wisconsin Sea Grant ..... 608-263-3259


Ontario Ministry  
of Natural Resources ..... 705-755-1950

Québec Ministère de l'Environnement  
et de la Faune ..... 418-521-3940 Ext. 4497



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